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Detecting Fever in Polish Children by Infrared Thermography

E.F.J. Ring*, A.Jung**, J.Zuber**, P.Rutowski***, B.Kalicki**, U.Bajwa*

** Medical Imaging Research Unit, Faculty of Advanced Technology, University of Glamorgan, Wales U.K.*
*** Dpt. of Paediatric, Nephrology and Allergic Medicine, Military Institute of Medicine, Warsaw, Poland*
**** PH Flir Systems AB, 05-509 Piaseczno Poland*

Abstract

Recent interest in fever detection by infrared thermography has shown that there is a lack of data on normal and febrile subjects. Furthermore, the highest at-risk group of the population in the event of a pandemic fever is in children and young parents. This study has been conducted in Warsaw to collect temperature data from 191 children, 173 normal and 18 febrile children in order to provide some reference data that may contribute to the consideration that an infrared imaging system used in future screening for fever is able to separate febrile from healthy children.

1. Introduction

Since the outbreak of SARS, Severe Acute Respiratory Syndrome, in S.E. Asia, it has become clear that thermography can be used to identify people with a high temperature who may be among a number of travellers, especially those arriving or departing from ports and airports. From two new documents produced by the Singapore Standards Organisation SPRING in 2003 an International writing group for the ISO and IEC have been working to define the minimum standards needed for the use of a dedicated screening thermograph. ISO TC 121/SC32-IEC TC/SC62D JWG8 PT1.This standard is nearing completion, and considers the testing and performance required to be able to discriminate between healthy subjects and those with a fever. Any with a raised temperature would be directed to a clinical screen where thermometry and brief clinical examination will be used to verify fever, or permit the traveller to continue on their journey.

There is limited published data on the identification of fever, but temperatures of 38°C and above located on the face, have been considered to be febrile [1,2]. An earlier study has shown that the face is an excellent site for monitoring temperature, particularly the inner canthi of the eyes. When ambient temperature is changed this area is one of the most stable locations. In a fever screening applications, there will be many locations where time cannot be given for the usual skin temperature stabilisation as used in clinical thermography. Therefore selecting the inner canthus of the eye to measure temperature is less dependent on the effects of ambient. Some earlier investigators have measured mean forehead temperature, but this has been shown to be less reliable, and influenced by exertion and physical activity. In this study we have examined 178 children in the paediatric clinic in Warsaw at different times of the year, to compare the range of normal temperatures from afebrile patients with those of known fever.

2. Methods

191 Children, both in and outpatients at the Paediatric Clinic in the Military Institute of Medicine in Warsaw (Dir. Prof. Anna Jung) were measured in a temperature stable room controlled at 23°C ±1°C. The age range was from 1 year to 17years, 107 female, and 66 males, mean age 6.8 yrs.

Body temperature was assessed by a clinical glass thermometer at the axilla (underarm) and by ear tympanic radiometry. They were seated on a chair and a FLIR infrared camera was positioned directly at the face, without rotation at the neck, with the camera plane parallel to the ground. The target area for measurement from the anterior facial thermogram was taken from two regions of interest, one rectangular area covering both eyes, the other a similar sized area located over the central forehead. Demographic information including date of birth was recorded. A small number of very young children were successfully imaged by being seated on their mother's lap facing the camera.

Three different FLIR systems IR cameras were used, with equal ease and reliability of measurement. Model 350, a FLIR 620 and the T400 used. A temperature reference source was used close to the subject at a constant temperature of 35°C. The camera was started each day and kept in position before the reference source at 0.5 meter. Temperature measurements did not commence before a fully stable measurement of the reference source was obtained. The small camera (figure 1) was mounted on a small table top tripod, positioned on a convenient low table. All other thermograms were recorded with the camera mounted on a single pillar stand, which avoids problems with parallax errors. The camera is more easily adjusted for height, being mounted on a bar that remains parallel to the floor.

Figure 1. *The small FLIR 350 camera mounted on a small table top tripod.*

Figure 2 *Tympanic ear radiometer and clinical thermometer used in the study*

3. Results

The four areas where measurements of temperature were obtained were axilla by clinical thermometer, tympanic ear temperatures, forehead mean temperature and inner canthi of the eyes. The tympanic membrane radiometer was not available on all occasions, hence the smaller number. Table 1 shows the data from the normal subjects.

Sites	**Axilla**	**Ear**	**Eye***	**Forehead***
Mean T	36.17	36.12	36.61	35.28
Std Dev	0.48	0.76	0.63	0.63
n subjects	169	75	173	173

Table1. *Temperature measurements obtained from 173 normal subjects,* from thermograms of the face, using a constant size region of interest.*

The mean temperature expressed from these two measurement sites is taken from the individual maximum temperature values measured from the standard sized regions of interest, and are recorded from a minimum of 9 pixels per measurement.

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The data obtained from 18 febrile children are shown in table 2. These measurements are based on an axilla temperature of <37.6°C. The highest temperature recorded in this group was 38.5°C. Four children who started on antibiotics following the assessment all had temperatures close to normal 24 hours later.

Area	Axilla	Ear	Eye	Forehead
Mean T	37.3	36	37.8	36.9
SD	0.4	1.1	0.9	0.8

Table 2. *Temperature measurements obtained from 18 febrile children.*

When the temperature measurements from the eye (thermographic) were compared to the axillar clinical thermometry data (Wilcoxon Signed Rank test) no significant differences were found. P <0.01

This is the recommended method according to the new ISO standard when using a screening thermograph for confirming fever in subjects with raised temperature at the inner canthus of the eye by thermal imaging.

The group of febrile children, showed significantly raised temperatures at the four measurement sites, but showed the best correlation between the eye and axilla thermometry temperatures, P > 0.05. Using the CHI squared test, the forehead measurements taken from the thermal images were less significant.

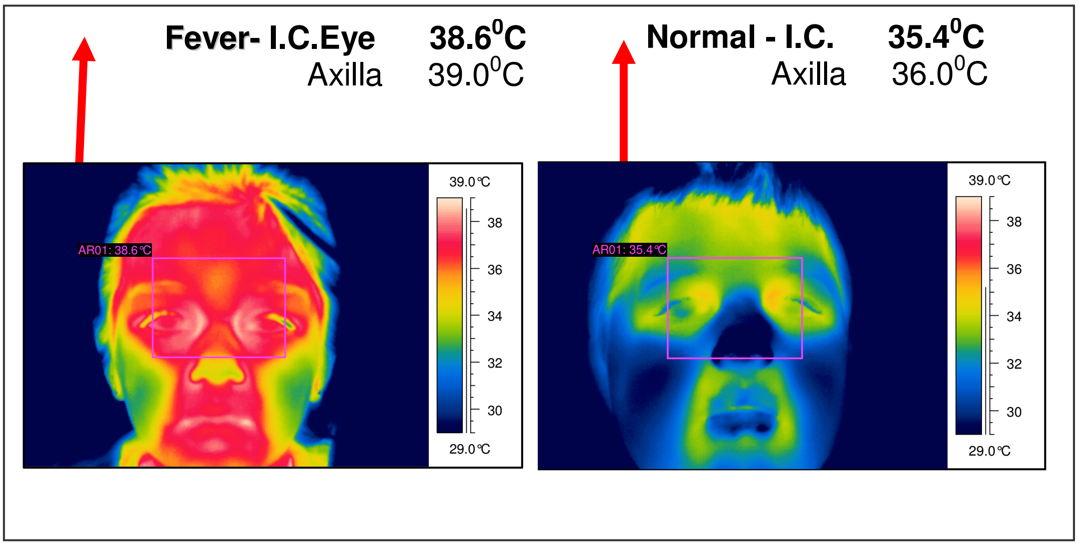

Figure 3. *Two 10 year old males, the left thermogram shows a case of fever, the right is normal (afebrile). The fever thermogram shows max t = 38.6°C at the inner canthi (i.c.) of the eyes, the axilla temperature by thermometry was 39.0°C. Both are > 38oC. The normal thermogram shows the inner canthi temperature max. to be 35.4°C, and the axilla thermometry temperature is 36°C.*

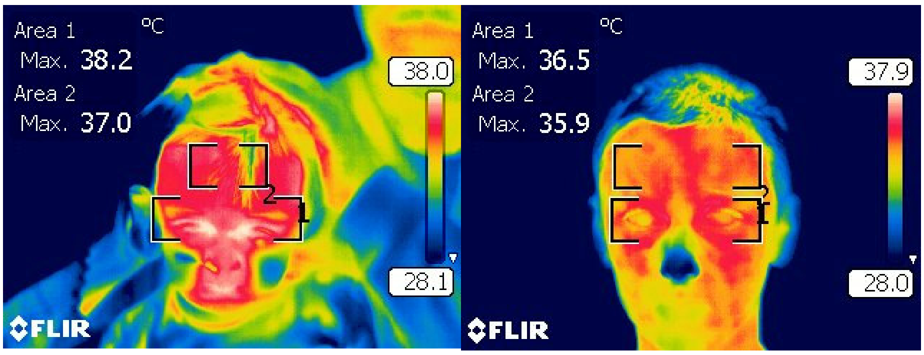

Figure 4. *The left thermogram is from a young child being held by a parent. This child has fever, with max. inner canthus temperature at 38.2°C, the forehead maximum is 37°C. The child on the right has sinusitis. Although the thermal pattern is changed, the temperatures are below fever level, and the thermometry under-arm is normal.*

4. Discussion

The data obtained from this study has provided some normative temperature values obtained from children who are free from fever. We have also shown that under normal ambient conditions, and with minimal disturbance to the subjects themselves we have demonstrated that fever can be detected with an infrared camera by measuring the maximum temperatures from the inner canthus region of the eye. Figure 3. When these values were compared right to left, no significant differences were found, so the mean of both eyes was used. Furthermore we found no association between age or gender of the subjects and overall temperatures measured. There were three subjects with uneven temperatures from both eyes, who had an episode of sinusitis. Figure 4. In these subjects difference in temperature between both eyes was 0.5, 0.4 and 0.5°C, but the axilla temperatures were normal. In all others the left to right difference was < 0.3°C. In screening for fever, it should be clear that unilateral temperature increase over one eye (and less than 37.5°C) with normal axilla temperature should not be regarded as a false positive for fever.

The data also suggest that temperatures measured above 37.5°C should be considered febrile, given the ±0.5°C tolerance of the measuring systems, rather than 38°C previously used in China during the SARS outbreak.
The earlier experience with airport passenger screening highlighted some problems when the camera was mounted high above the travellers. Wearing hats, sunglasses, normal spectacles, even face masks were encountered, all of which interferes with the reliable recording of the eye region of the face. Our data indicates that the most reliable way to detect the temperature is from a correctly aligned IR camera, possibly with a digital photo camera. With a few precautions, and the subject looking directly into the IR lens, fast and reliable temperatures can be recorded.

We found the forehead temperature readings to be less reliable. Studies in The Netherlands have shown that physical exercise can cause changes in forehead temperature, and for screening passengers this would clearly be a problem. Tympanic temperature measurements by radiometry have become very popular in many countries, often replacing glass thermometers for routine clinical assessment of temperature. However, these are also subject to problems, from the irregular and different shapes of the human ear canal, and the presence of cerumin (wax) that can interfere with the temperature target area [3].

The good correlation between axilla temperature and inner canthus of the eye shown in this study is a confirmation of the future potential for thermal imaging in fever detection. The image provides an overall picture of the heat of the face, generally not just located around the eyes in general fever. Software is available that can be used to automatically locate the region of interest, and maximum temperatures can be obtained that can trigger a visible and or audible alarm. We have taken care to avoid the possibility of recording a maximum temperature that could arise from a single pixel value. Most software systems should obtain this value from a small cluster of pixels, and this is included in the new ISO specification.

An important aspect of this study is that the conditions for temperature measurement of the face must be optimal. Standardisation of technique is very important. The image should fill the frame as much as possible in order to maximise the number of pixels available with the regions of interest. Wherever possible to subject should be facing the camera lens and the camera should be positioned at eye level. The only time this was compromised in the study was with a small number of very young children who were restless and where held by a parent briefly during image capture. The use of a height adjustable single pillar stand was crucial for rapid and accurate positioning. Aspects of standardisation have been described in other publications. [4,5]

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